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DEVELOPMENT OF MESOSCALE AIR QUALITY SIMULATION MODELS
VOLUME 6. USER'S GUIDE TO MESOPAC (MESOSCALE METEOROLOGY PACKAGE)

Carl W. Benkley
Arthur Bass

Environmental Research & Technology, Inc.
696 Virginia Road
Concord, MA 01742

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Project Officer

Herbert J. Viebrock
Meteorology Laboratory
National Oceanic and Atmospheric Administration
Research Triangle Park, NC 27711

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16. Abstract (Limit: 200 words)

MESOPAC is a mesoscale meteorological preprocessor program; it is designed to provide meteorological data to regional-scale air quality simulation models. Radiosonde data routinely available from National Weather Service (NWS) radiosonde ("upper air") and surface stations are used to produce spatially-interpolated, time-sequenced mesoscale meteorological data fields. These include: (a) horizontal (u,v) wind components; (b) mixing depth; (c) Pasquill-Gifford-Turner (PGT) stability class. An interpolation/iterative relaxation scheme is used to construct the wind field. The mixing depth and PGT stability fields are created with a new physically appealing algorithm.

MESOPAC is a fully-independent program, easily coupled to any reasonably modular transport-diffusion model. Currently, it is used to drive the MESOPUFF, MESOPLUME, and MESOGRID models. MESOPAC is highly user-oriented: easy to understand; easy to use; easy to modify. It offers a range of features including: user-specified grid resolution (maximum resolution is 40 x 40 elements); arbitrary grid orientation and size; user-specified data stations and significant data levels (e.g., surface, 850 mb, 700 mb); user-controllable minimization of wind field divergence; time-weighted (centered) interpolation of data fields; arbitrary duration of meteorological episode; and multiple choices of output time interval (1, 2, 3, 4, 6, or 12 hours).

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1. INTRODUCTION

1.1 Background

In response to a growing national commitment to the use of indigenous coal reserves to meet energy generation demands, several regions of the country will see greatly expanded use of coal and oil shale resources for steam electric power plants and other coal-based energy resource development. But, as mandated by federal National Ambient Air Quality Standards, and by the PSD major source review procedures, additional coal-based energy resource development (ERD) will only be permitted where consistent with the maintenance of human health, welfare, and environmental quality. Accordingly, the siting and generation capacity of such ERT facilities will be constrained by their potential impacts on regional ambient air quality.

Various plans have been proposed for regional development of multiple major new facilities and suitable air quality simulation tools are needed to assess the impacts of different energy development scenarios on regional-scale air quality. To meet this need in the public interest, the National Oceanic and Atmospheric Administration (NOAA) has sponsored a study by Environmental Research & Technology, Inc. (ERT) to develop, compare, evaluate, and exercise a number of alternative approaches to regional-scale ambient air quality modeling. A major objective of this study is to provide a suite of air quality simulation models that are both technically sound and computationally practical for assessing regional-scale impacts of energy development scenarios.

As described in the companion report, Volume 1 (Bass et al. 1979) three long-range transport-diffusion models - MESOPUFF, MESOPLUME, MESOGRID - have been developed, implemented and compared for the simulation of multiple point-source plume dispersion on the mesoscale [e.g., dispersion at ranges of 100 to 1,000 kilometers (km)]. These models are optimized for regional-scale impacts; they have been designed to treat a broad range of meteorological situations (both worst-case and average dispersion conditions) over periods of several days to several weeks; they are easy to use for a variety of decision-making and regulatory applications; and are also intended as flexible testbeds for further research, development and simulation tasks.

The MESOPUFF, MESOPLUME and MESOGRID models - like many regional-scale air quality transport-diffusion models - are driven by spatially-gridded time sequences of meteorological fields. MESOPAC - a flexible, fully-independent mesoscale meteorological preprocessor program - is designed to provide the input meteorological data to these and similar regional-scale air quality simulation models. Radiosonde data routinely available from National Weather Service (NWS) radiosonde ("upper air") and surface stations are used to produce spatially-interpolated, time-sequenced mesoscale meteorological data fields, including (a) horizontal

(u,v) wind components; (b) mixing depth; and (c) Pasquill-Gifford-Turner (PGT) stability class. MESOPAC is highly user-oriented, with optimal features that make it an attractive tool for a range of practical problems.

This report, the sixth in a series entitled "Development of Mesoscale Air Qulity Simulation Models", describes MESOPAC in technical detail; illustrates its application and provides a User's Guide to the program. However, to obtain a fuller understanding of MESOPAC's use in driving regional-scale air quality transport-diffusion models, the user may wish to refer to the following related reports:

- the companion report (Volume 1) describing the multiday meteorological episodes and extensive series of comparison and model sensitivity analyses performed with the MESOPUFF, MESOPLUME and MESOGRID models (Bass et al. 1979);
- the companion User's Guides (Volumes 2-4) to the MESOPLUME, MESOPUFF and MESOGRID models, respectively (Benkley and Bass 1979a; Benkley and Bass 1979b; Morris et al. 1979); and
- the companion User's Guide (Volume 5) to the special post-processing and analysis system MESOFILE (Scire et al. 1979).

1.2 Integrated Mesoscale Modeling System

MESOPAC has been incorporated as an independent model element within an efficient, easy to use integrated mesoscale modeling system. This integrated system depicted in Figure 1-1, comprises components for meteorological preprocessing, mesoscale transport-diffusion, and post-processing. Standardizing model input/output functions in this system permits easy combination of results from two or more model runs, or direct and cost-effective comparison of simulations performed with two or more different models for identical input meteorology (see, for example, Bass et al. 1979). As shown, MESOPAC drives identically any of the three mesoscale transport-diffusion models. In turn, each of these models identically communicates its results to the MESOFILE postprocessing system - responsible for file management, display, and statistical analysis of all model output fields.

1.3 Organization of the Report

Section 2 of this report contains a detailed technical description of MESOPAC; specific user instructions and a test case for MESOPAC is presented in Section 3.

A Fortran microfiche listing of the MESOPAC model is appended.

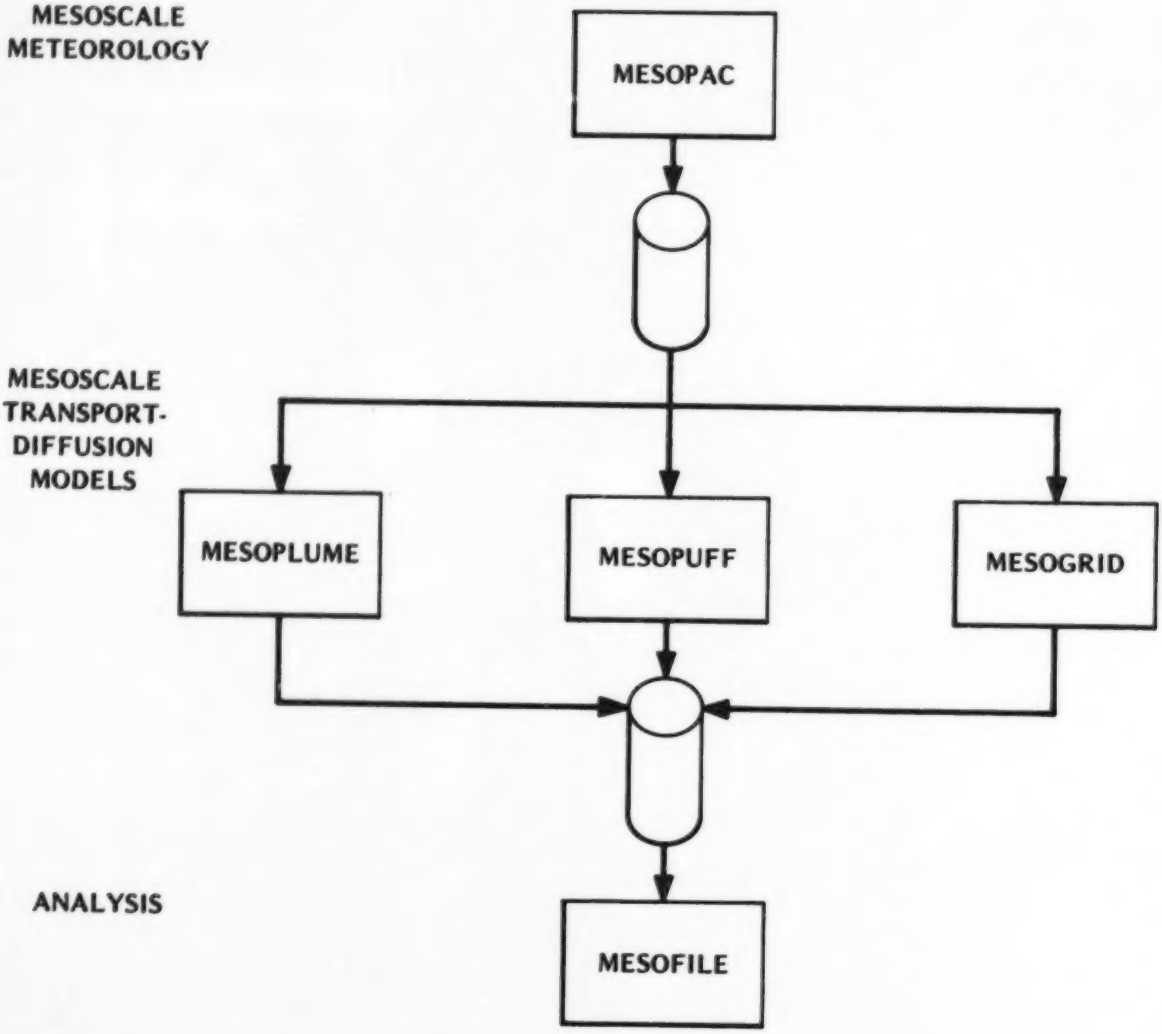

Figure 1-1 Integrated MESOSCALE Modeling System

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2. MODEL DESCRIPTION

This section presents the essential algorithms of MESOPAC wind field, mixing depth, and stability determination. Section 2.1 discusses how the wind field is produced by an inverse-squared weighing technique and a divergence-minimization algorithm. At each point, the mixing depth field is computed as the maximum value of convective and mechanical mixing depth production methods, as detailed in Section 2.2. Section 2.3 describes how the consideration of wind speed and strength of convection is used to compute a Pasquill-Gifford-Turner (PGT) stability at each grid point.

2.1 Wind Field Algorithm

At each time step, the MESOPAC model produces a gridded field of rectangular (u,v) wind components from National Weather Service (NWS) radiosonde wind data. This gridded field can be produced at whatever pressure level or height above sea level the user feels is most applicable to his specific dispersion problem. If terrain heights vary appreciably over the grid, the user may even wish to choose individual station measurement heights so that a terrain-following windfield is simulated. It is suggested that if mandatory pressure levels are only considered, fields constructed from the 850-millibar (mb) surface, without any speed or direction scaling, may be more relevant to the dispersion of a contaminant uniformly mixed through the boundary layer than surface or 700-mb winds. If the terrain is high, however, the 700-mb surface must be chosen in lieu of the 850-mb surface. The wind components at each radiosonde station at radiosonde observation times are interpolated to intermediate hours. Figure 2-1 illustrates the time-dependent behavior of a hypothetical quantity, F, given values of F_0 at 12Z and F_1 at 00Z. In this example, the time-dependent weighing between radiosonde times is linear, although MESOPAC optionally allows for square-like; sinusoidal ($0.5*[1 + \cos\theta]$, $-\pi \leq \theta \leq 0$); or user-specified weighting factors as well. In Table 2-1, station wind data at radiosonde stations A and B at 12Z and 00Z are linearly interpolated to the intermediate hour, 18Z. (Note that the choice of units for velocity is arbitrary in this example.)

Once u,v station wind components are produced at the desired time step, MESOPAC computes gridded u,v fields using a wind field analysis technique that is essentially the same (except for a modification to the boundary conditions) as the analysis technique of Clark and Eskridge (1977). Only a brief description of the Clark and Eskridge algorithm is given here; for a more detailed treatment, the reader is referred to the original paper.

At each grid point, an initial windfield is generated at each time step by inverse-square radius weighting (separately in both wind components), for all stations within one scan radius of the grid point. The scan radius is computed internally as the largest distance between

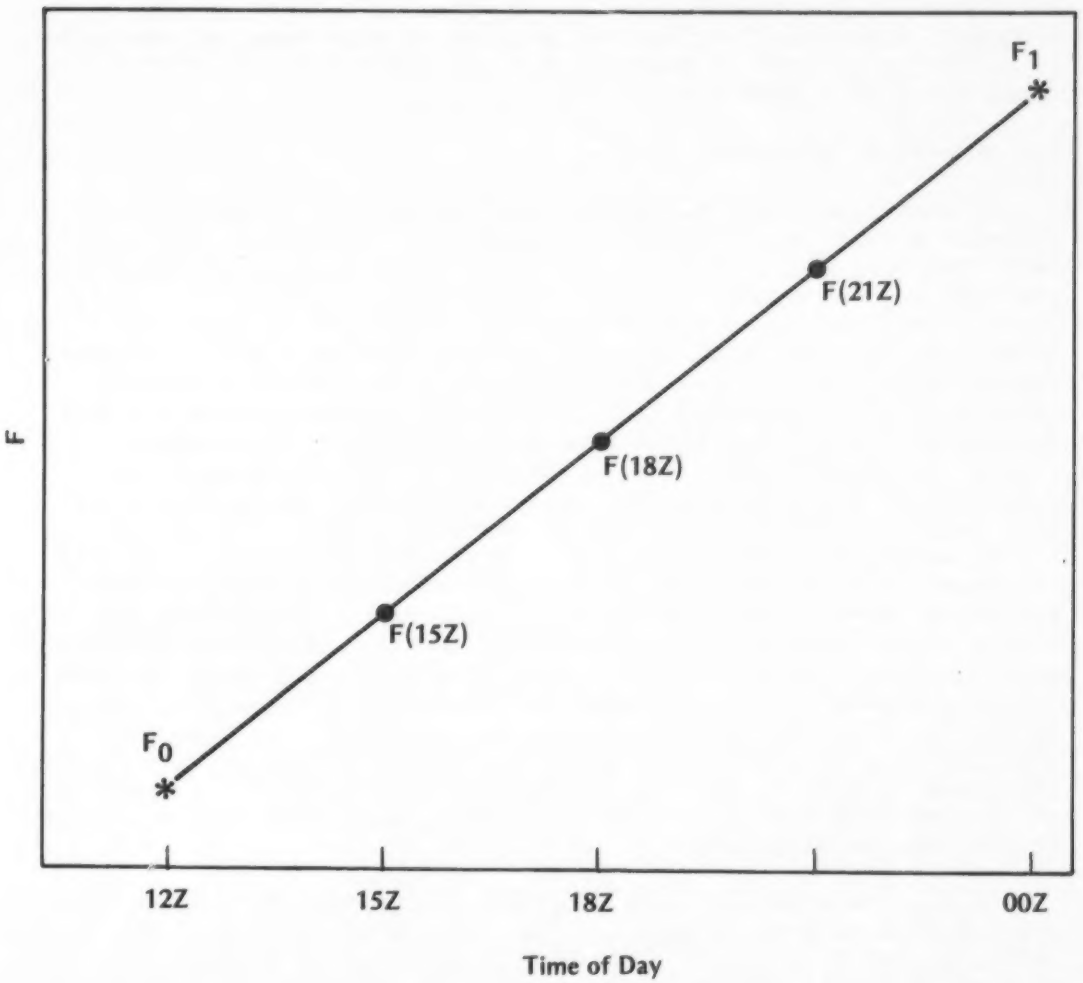

Figure 2-1 Linear Interpolation of a Time-Dependent Quantity

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TABLE 2-1

TIME INTERPOLATION OF STATION WIND VECTORS

Station	Measured 12Z		Measured 00Z		Interpolated 18Z	
	u	v	u	v	u	v
A	10	0	4	6	7	3
B	2	-3	4	-7	3	-5

any grid point and the radiosonde station nearest that grid point, plus an additional 0.5DX, where DX is the grid spacing. The user may specify a larger scan radius, thereby forcing the model to compute a smoother but possibly less realistic initial wind field. Choosing a scan radius much smaller than the model-computed scan radius would result in there not being at least one radiosonde station within one scan radius of every grid point.

A simplified example of the scan radius determination (for only two radiosonde stations) is illustrated in Figure 2-2. Here, Station A lies at x = 1.5, y = 1.5 on the 4 x 4 grid. (Note that the lower left hand corner point has coordinates x = 0.0, y = 0.0.) Station B lies at x = 3.0, y = 0.0. The scan radius r (the distance from Station A to each grid point at each of the four corners of the grid, + 0.5 DX), is then

$$r = \sqrt{x^2 + y^2} + 0.5\ DX = 2.62\ DX \qquad (2\text{-}1)$$

Only the grid points in the shaded area fall within one scan radius of both radiosonde stations. For the text example, the initial windfield is illustrated in Figure 2-3. Note that since Station B falls directly on a grid point, the weighting technique is overridden, and the actual wind components of Station B are used at that grid point.

The initial wind field may have significant divergence. Because some numerical mesoscale diffusion models (e.g., MESOGRID) require essentially divergence-free windfields, a program option can be exercised to minimize the divergence of the wind field to within a certain tolerance. [The tolerance is defined as the maximum allowable divergence at any grid point. This tolerance can be specified by the user; otherwise, a tolerance of 10^{-5} (s^{-1}), a typical value for mesoscale-scale divergence, is used.]

The divergence at each grid point is minimized by adjusting wind components at adjacent grid points. Successive outward iterations gradually force the divergent wind field components beyond the boundaries of the grid. A number of iterations are required to minimize wind field divergence over the entire grid, because minimizing the divergence at any point in the grid causes the adjustment of wind components and creation of divergence at adjacent points back towards the center of the grid.

The Clark and Eskridge algorithm uses a zero-gradient boundary condition. MESOPAC conserves mass over the entire grid at each iteration by adjusting u-components on the east and west boundaries and v-components on the north and south boundaries so that the net mass flux across the boundaries of the grid is zero.

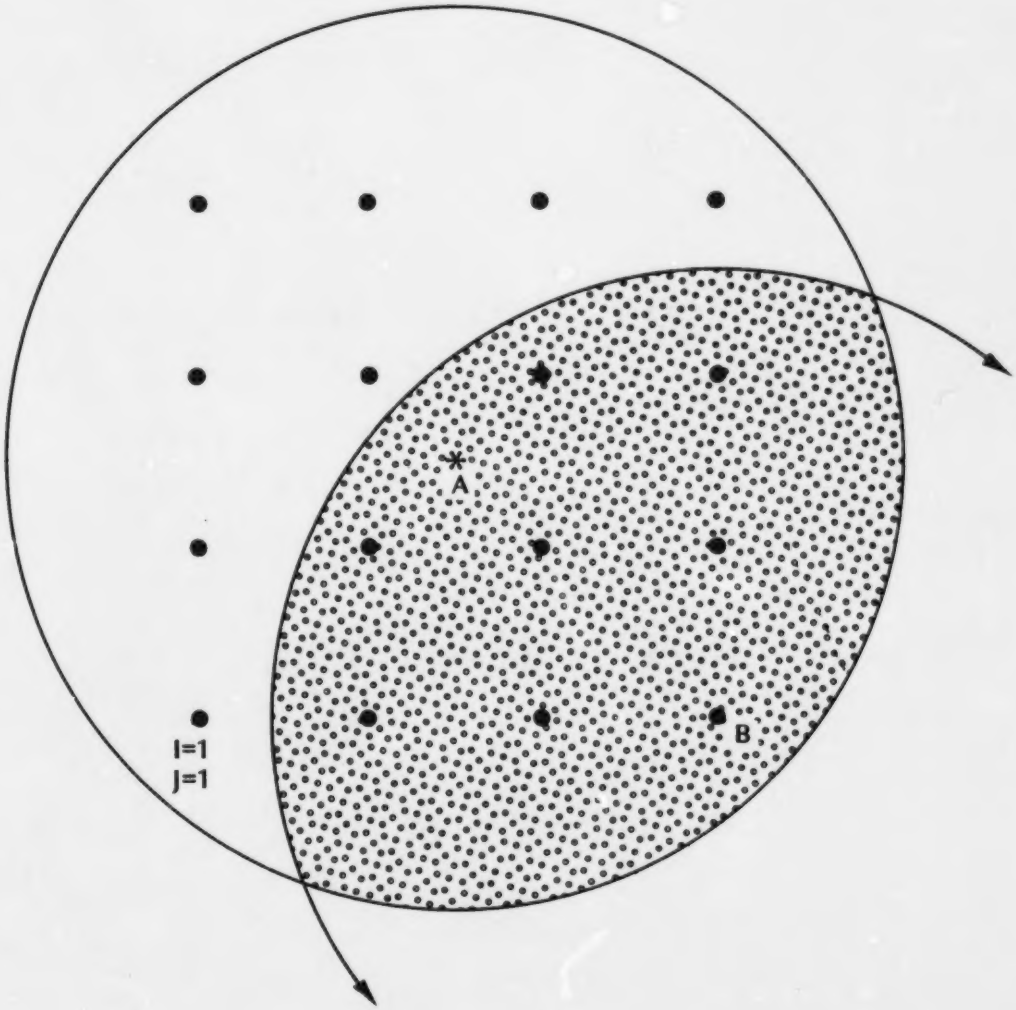

Figure 2-2 Scan Radius Determination

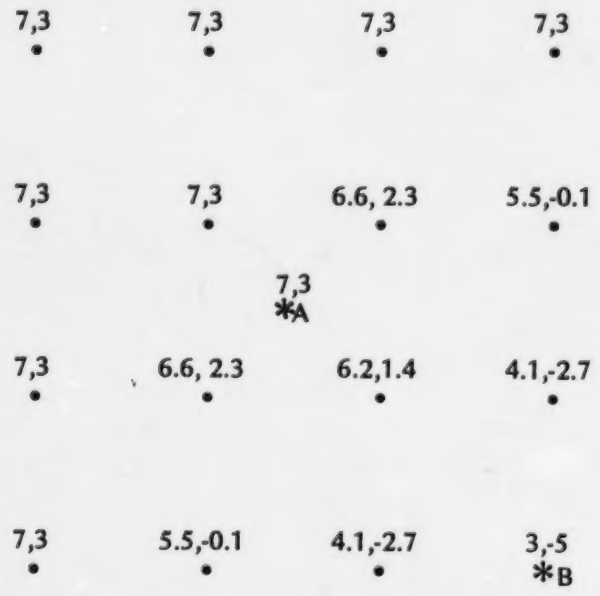

Figure 2-3 Interpolation of Station Winds (u,v) to Grid Points

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An additional program feature available during the relaxation process enables the user to select a variable maximum amount (0% to 100%) by which gridded wind components in the immediate vicinity of radiosonde stations are permitted to vary (see Clark and Eskridge 1977). A 0% allowance is equivalent to holding the wind components fixed at the grid point nearest a radiosonde station; at the other extreme, a 100% allowance means that no special emphasis is placed on these grid points nearest station locations.

2.2 Mixing Depth Algorithm

2.2.1 Rationale

If desired, MESOPAC computes gridded fields of mixing depth at each model time step. The mixing depth algorithm is derived from simplifying and generalizing, for regional scales, the site-specific algorithm of Benkley and Schulman (1979). For each mixing depth grid, the mixing depth at each point is computed as the larger of two independent values: a mechanical value and a convective value, respectively. Atmospheric boundary layers are nearly always turbulent, and the growth or maintenance of this turbulent mixed layer stems from the mechanical (wind shear) production of turbulence and the convective (buoyant) production of turbulence. Mechanical production and convective production often occur simultaneously, but, in many instances, a first approximation may indicate one mechanism to be appreciably stronger than the other. For example, when the earth's surface cools at night, only mechanical turbulence can form or maintain a turbulent mixed layer (convection is probably nonexistent). Therefore, the mixing depth can be computed through mechanical considerations alone. Conversely, strong daytime heating frequently results in convective production of turbulence that greatly exceeds mechanical production. The resultant deep mixed layer can therefore be described in terms of convective production alone. On cloudy or windy days, however, mechanical production and convective production may be of the same order. It is therefore necessary during daytime hours to choose the mixing depth as the maximum of the mechanical and convective values, because it is not always evident whether one of the production methods will be dominant.

The mechanically produced mixing depth, H_m, computed at 00Z and 12Z each day, is related through a scaling argument to the friction (shear) velocity u_* and the Coriolis parameter f.

$$H_m = cu_*/f \qquad (2\text{-}2)$$

This parameterization of the mechanically produced mixing depth is consistent with the work of many researchers, including Clarke (1970) and Deardorff (1972). Yu (1978) concluded that such a parameterization is as good as or better than stability-dependent or time-dependent parameterization. Values indicated for the constant, c, range from

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about 0.05 (Delage 1974) to 0.3 (Deardorff 1972). Based on theoretical and empirical considerations, Plate (1971) derived c = 0.185. The data of Benkley and Schulman (1979) indicated a value of about 0.15. Assuming that c = 0.15 and that u_* is approximately 3.5% of the free-stream velocity, u_g (Blackadar 1962), the mixing depth equation can be expressed as:

$$H_m = 53 \times 10^{-4} u_g/f \qquad (2\text{-}3)$$

The convectively produced mixing depth H_c is assumed to be zero at 12Z daily, approximately at the time of sunrise, and the time of minimum surface temperature for longitudes typical of the contiguous United States. Consequently, the convective production of turbulence and the resultant growth of the daytime convective mixed layer has not yet started. From 12Z to 00Z, assuming that the surface temperature increases, convective production of turbulence increases the mixing depth. A maximum mixing depth is reached at approximately the time of maximum surface temperature. On an adiabatic chart, H_c is obtained as the height of the intersection of an adiabat drawn upwards from the 00Z surface temperature T_{00}, with the morning temperature sounding, as illustrated in Figure 2-4. The area between the adiabat and the morning sounding is proportional to the convective production of turbulence, integrated over the daytime hours. In rare cases, an adiabat drawn from T_{00} may not intersect the morning sounding below the highest mandatory level the model includes (500 mb). H_c is then assigned as the height of the 500-mb surface above ground.

Because 00Z generally follows the time of maximum surface temperature in the continental United States, this method may somewhat underestimate the maximum afternoon mixing depth, especially in eastern and central time zones. So, if available, the user may substitute the afternoon maximum surface temperature for the 00Z radiosonde station temperature.

2.2.2 MESOPAC Mixing Depth Determination

At each time step in the model, a field of mechanically derived mixing depths is produced. If the divergence-free wind field option has not been exercised, then the mechanical mixing depth at each grid point is computed from the wind velocity derived from the u and v wind components that were directly interpolated to that grid point. If the wind fields are divergence-free, then the mechanical depths are based on the speeds derived from wind components at respective grid points after the divergence of the entire field has been minimized. Thus, the mechanical mixing depth field is consistent with the velocity-dependent production of mechanical turbulence at each grid point, as specified by the wind field model.

As an example of the computation of the mechanical mixing depth field, the wind components at 18Z from Figure 2-3 are used. At each grid point, the mechanically produced mixing depth is $H_m = 53\ u_g$, where

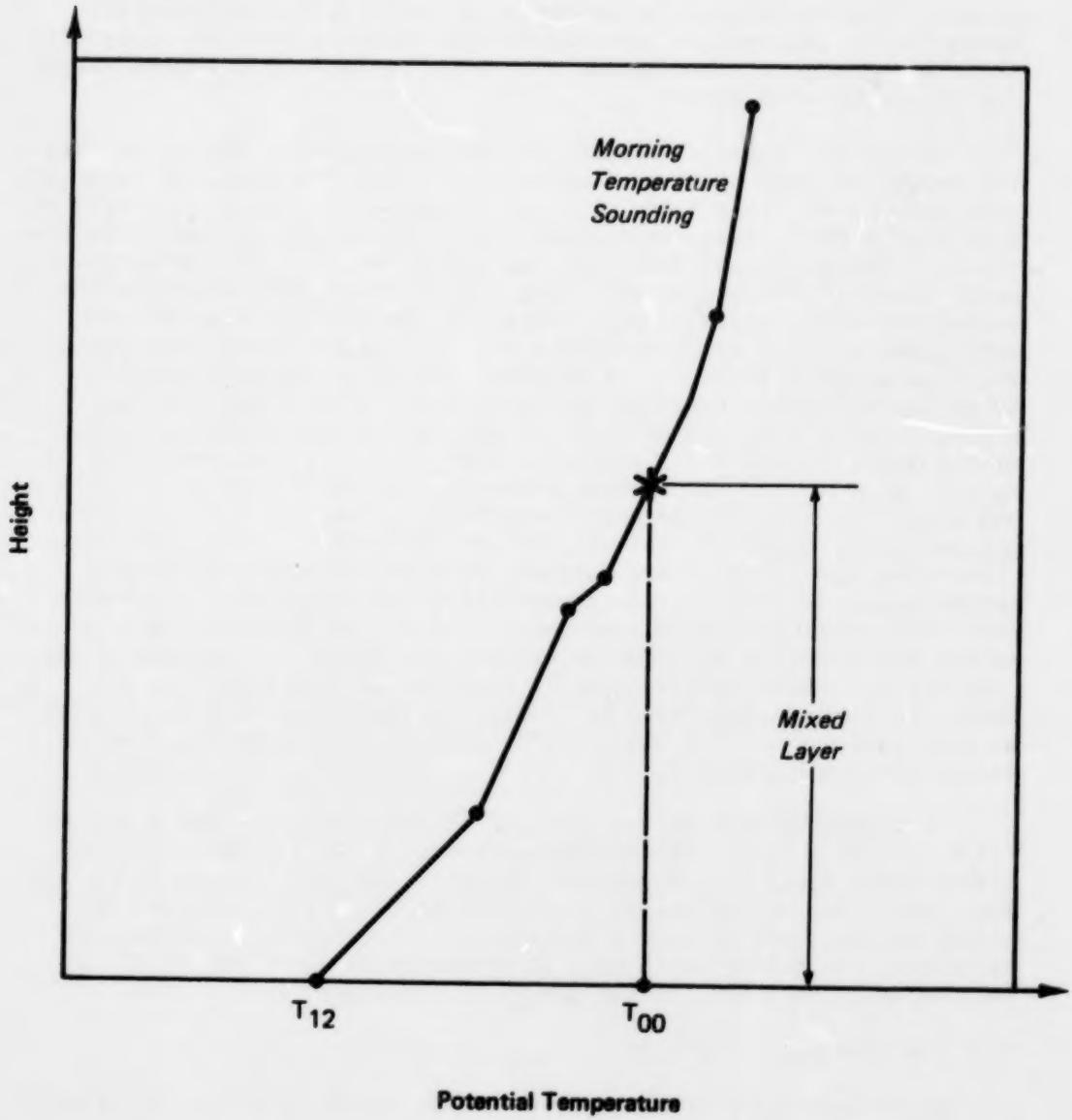

Figure 2-4 Estimation of the Maximum Daytime Convective Mixing Depth

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$u_g = \sqrt{u^2 + v^2}$. If u = 7 and v = 3, then H_m = 404 m. The entire gridded field is reproduced in Figure 2-5. Note that the mixing depths at four points on the grid are lower than those of the two station mixing depth values. This is because the weighting of individual wind velocity components to grid points from two or more stations does not necessarily yield the grid point wind speeds that would be derived by direct weighting of station wind speeds.

For the hours 01Z to 12Z inclusive, convection is negligible, and the mechanical method alone adequately describes the mixing depth at all grid points. At other hours, 13Z to 00Z inclusive, the mixing depth at each grid point is taken as the maximum of the mechanical and convective values. The mechanical field is computed as before. The convective depth field is produced at each time step by first time-weighting the convective mixing depth at each station to the desired time and then interpolating these weighted depths at each station to all grid points. The time-weighted mixing depth at each station is computed by the weighting technique described in Figure 2-1. In this example, the mixing depth $H_c = F_0 = 0$ at 12Z. As daytime heating progresses, the mixing depth increases linearly with time, reaching a maximum value of $H_c = F_1$ at 00Z.* If the maximum convective mixing depths at Stations A and B are 750 and 1,000 meters, respectively, then the linearly interpolated mixing depths at 18Z are 375 and 500 meters. After the station convective mixing depths are derived, they are interpolated to grid points using the same inverse-square radius technique used to produce the fields of initial wind components. Given that H(station A) = 375 meters and H(station B) = 500 meters at 18Z, Figure 2-6 represents the convectively producing mixing depth field on the 4 x 4 grid at 18Z. The composite field is generated by finding the maximum mixing depth value at each grid point. For the example case, the composite field is represented in Figure 2-7.

As a general rule in the analysis of mixing depths, the composite field will be a clear representation of the actual spatially varying mixing depth field as produced by the mechanical and convective forcing functions. Regions on the grid with strong winds will exhibit deep mixing depths, even without convection. Without dominant mechanical influence, the mixing depth will be dependent on the strength of convection and, therefore, on the amount of cloudiness in a region.

2.3 The Stability Algorithm

As an option, MESOPAC computes gridded fields of PGT stabilities each model time step at each grid point. The normal method for computing PGT stability (Turner 1970) relies on wind speed and solar insolation data during the day and wind speed and cloud cover data at night. Wind speed at each grid point is readily available in MESOPAC, but solar insolation and cloud cover data are not. Certain assumptions can be made enabling MESOPAC to compute realistic stabilities.

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*The user has the option to constrain the convective mixing depth to grow from $H_c = F_0 = 0$ at 12Z to $H_c = F_1$ at a user-specified hour between 12Z and 00Z; $H_c = F_1$ will then persist until 00Z.

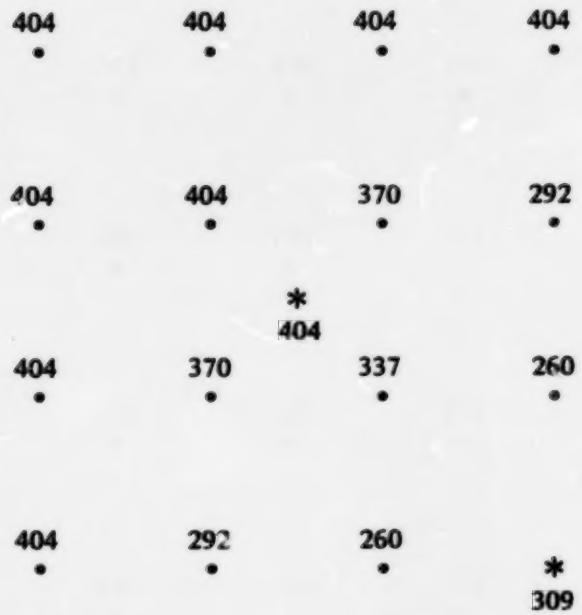

Figure 2-5 Mechanically Produced Mixing Depths

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Figure 2-6 Convectively Produced Mixing Depths

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Figure 2-7 Final Mixing Depth Field

At night, PGT stability is primarily wind-speed dependent. Low cloud coverage can, at most, alter the stability by one PGT class and then only for wind speeds less than 5 meters per second (m/s). At night, MESOPAC assumes partly cloudy conditions so that the computed stability is an average of the stabilities in Turner for cloudy and clear conditions.

During the day, the PGT stability is as dependent on incoming solar radiation (and the convective turbulence it produces) as it is on wind speed. Because the depth of the convective mixed layer is dependent on incoming solar radiation in much the same manner as PGT stability is, it follows that the strength of incoming solar radiation can be estimated from the depth of the daytime convective layer. As a rough estimate, MESOPAC assumes weak insolation when the mixing depth by convective considerations is $H_c < 500$ m; moderate insolation when 500 m $< H_c <$ 1,000 m; and strong insolation when $H_c >$ 1,000 m.

Considering a day with a maximum afternoon convective depth $H_c >$ 1,000 m, it follows that the PGT stability goes from Class C to Class A as the mixed layer deepens from zero at sunrise to greater than one kilometer by afternoon. The solar elevation angle increases from 0° at sunrise to a probable elevation angle greater than 60° at midday, ensuring that sufficient insolation produces a deep convective layer. With these considerations in mind, Table 2-2 is constructed in a form consistent with Turner.

Assuming a logarithmic wind profile in the surface layer with the roughness length 10 centimeters and the Von Karman constant 0.35; and, as in Section 2.2.1, the friction velocity $u_* = 0.035\ u_g$ (u_g is the free stream velocity), the free stream velocity is scaled by a factor of 0.46 to produce a value of u (10 meters) at each grid point for use in determining the PGT stability from Table 2-2.

In the example problem at 18Z, all the convective depths in Figure 2-6 are below 500 meters except at the point I = 4, J = 1, and therefore imply light insolation. Because wind speeds at 10 meters are all within 2 to 5 m/s, then the PGT stability is taken as Class C. At the point I = 4, J = 1, insolation is moderate, and u (10 m) = $0.46\ u_g$ = 2.68 m/s, resulting in a PGT stability of Class B. The PGT stability field is presented in Figure 2-8. Where two stability classes appear in Table 2-2 for the same wind speed range, MESOPAC uses the more unstable class for the lower end of the wind speed range during the day and the more stable class for the lower end of the range at night.

TABLE 2-2

KEY TO PGT STABILITY CLASSES AS GENERATED BY MESOPAC

Surface Wind Speed at 10m ($m\ s^{-1}$)	Day			Night
	Mixing Depth			
	$H_c \geq 1000m$	$500 \leq H_c < 1000$	$H_c < 500$	
<2	A	A-B	B	
2-3	A-B	B	C	E-F
3-5	B	B-C	C	D-E
5-6	C	C-D	D	D
>6	C	D	D	D

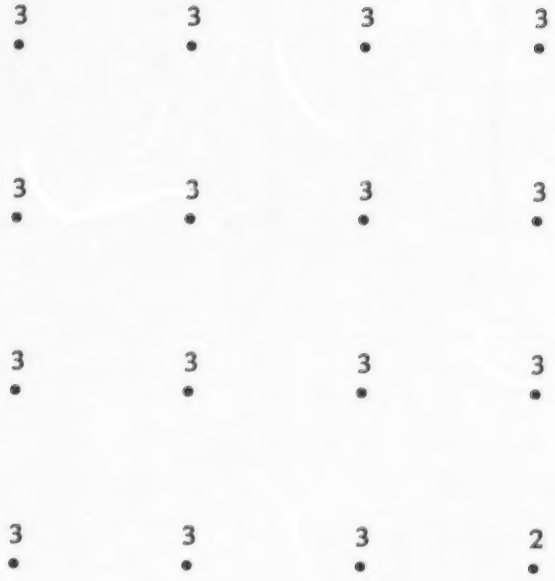


Figure 2-8 The PGT Stability Field

807099

3. USER'S MANUAL

The MESOPAC user's manual provides a detailed description of the preparation of a model run. A test example is proposed for illustrative purposes; both the model input and output are included for the test case. In addition, the entire program listing is appended in microfiche. [The Fortran listing may appear somewhat unusual--the actual Fortran code shown here was machine-translated from a higher-level language, RATIONAL FORTRAN (RATFOR)].

3.1 Model Input

3.1.1 Description

MESOPAC input is divided into two separate parts, parameter input and meteorology input. Both files are coded in card image form as one composite file, and input via logical unit 5. As detailed in Section 3.1.2, the parameter input contains all the variables necessary to define any MESOPAC run. Grid size, run length and time step, and radiosonde station names and locations are some of the key input parameters. In addition, various program options are specified through the choice of other input parameters. The second input data file, radiosonde input (Section 3.1.3), contains the wind components, temperature, and pressure data at radiosonde stations. The data file, input daily during the run stream at 00Z and 12Z, must begin at or before the desired starting time input from the parameter file. Two radiosonde sets are necessary for a 12-hour run, three sets for a 24-hour run, and, in general, N + 1 radiosonde sets for a 12*N-hour run. Because the model recognizes station names, it is not necessary to keep station data cards in any particular order for any radiosonde set. Also, if one station's data are missing, that station's card can be omitted at that time. Detailed input description for the meteorology file is given in Section 3.1.3. Note that because of the way the mixing depth algorithm works, pressure and temperature data are only necessary for the morning (12Z) soundings.

3.1.2 Parameter Input

Card #	Columns	Format	Name	Definition
1	1-76	38A2	HEAD(38)	Title for output data tape.
1	77-80	I4	METCOD	4-digit integer code for output tape.
2	1-5	I5	IMAX	Number of grid intersections in the x-direction (a maximum of 40 are allowed).
2	6-10	I5	JMAX	Number of grid intersections in the y-direction (a maximum of 40 are allowed).

Card #	Columns	Format	Name	Definition
2	11-15	I5	NMAX	Number of radiosonde stations (a maximum of 40 are allowed).
2	16-20	I5	ISTEP	Time step (hours) between output maps, (allowable time steps are 1, 2, 3, 4, 6, and 12 hours).
2	21-25	I5	ICOEF	Weighting coefficient for the time interpolation of station winds to ISTEP intervals (1-linear, 2-sinusoidal, 3-square-like, 4-user-specified).
3	1-2	I2	IHRBEG	Beginning hour of program run.
3	3-5	I3	IDYBEG	Beginning Julian day of run.
3	6-7	I2	IYRBEG	Beginning year of run.
3	11-12	I2	IHREND	Ending hour of run.
3	13-15	I3	IDYEND	Ending Julian day of run.
3	16-17	I2	IYREND	Ending year of run.
4	1-10	F10.0	DX	Grid space (meters). Defaults to 40,000 if field is blank.
4	11-20	F10.6	EPSI	Windfield relaxation (if desired) terminates when divergence at every grid intersection is less than EPSI. EPSI defaults to .00001 (s^{-1}) if field is blank.
4	21-30	F10.6	RADIUS	Scan radius (in units of grid space, DX) for interpolation of station winds to grid points. RADIUS is computed internally if field is left blank.
4	31-40	F10.6	WFRAC	Maximum allowable fraction (0.0 to 1.0) that individual wind components can vary at grid points near stations during wind field relaxation.
4	41-50	I10	KKMAX	Windfield relaxation (if desired) terminates after KKMAX iterations if EPSI criterion has not already been met. KKMAX defaults to 50 if field is left blank.
5	1-10	L10	DVFREE	If DVFREE = .TRUE., output wind-fields are "divergence-free". If DVFREE = .FALSE., output wind fields are not divergence-free.

Card #	Columns	Format	Name	Definition
5	11-20	L10	HMODEL	If HMODEL = .TRUE., the described mixing depth calculation is performed.
5	21-30	L10	LSTAB	If LSTAB = .TRUE., PGT stability fields are generated.
6	1-10	L10	LTAPE	If LTAPE = .TRUE., generated fields are output to tape or disk every ISTEP hours. If LTAPE = .FALSE., there is no output to tape or disk.
6	11-20	L10	LPRINT	If LPRINT = .TRUE., generated fields are output in gridded form every ISTEP * IPRFRQ hours. If LPRINT = .FALSE., there is no gridded output.
6	21-25	I5	IPRFRQ	For LPRINT = .TRUE., printing frequency is in terms of ISTEP for gridded fields.
6	29-30	I2	NHRZ	Hour (13Z < NHRZ < 00Z) at which the maximum daytime convective mixing depths at all stations are constrained to be reached. If NHRZ precedes 00Z, the model persists the maximum depths from NHRZ to 00Z.

One of the following cards is needed for each of the NMAX (total number) of radiosonde stations.

Card #	Columns	Format	Name	Definition
7...	2-4	A3	NAME(N)	Radiosonde station name.
7...	6-10	F5.1	XS(N)	x-coordinate of radiosonde station (N); XS(N) = 0.0 corresponds to I = 1.
7...	11-15	F5.1	YS(N)	y-coordinate of radiosonde station (N); YS(N) = 0.0 corresponds to J = 1.

The following card is read only if a specified option is requested.

Card #	Columns	Format	Name	Definition
last	varies in length	12F5.2	COEFF (4, ISTEP)	If ICOEF = 4, these time-interpolative weights are used to construct station winds from hours, t = ISTEP to t = 12, at ISTEP hour intervals between radiosonde times. COEFF (ICOEF, ISTEP) = 0.0 means that the wind components at the beginning of the time period are used. COEFF (ICOEF, ISTEP) = 1.0 means that the wind components at the ending radiosonde of the 12-hour period are used.

3.1.3 Radiosonde Input

Card #	Columns	Format	Name	Definition
1	1-2	I2	NCH	Hour (00Z or 12Z) of radiosonde set that follows.
1	3-5	I3	NDY	Julian day of following set.
1	6-7	I2	NYR	Year of following set.
1	11-15	I5	NSTAT	Number of radiosonde stations reporting at this year, day, hour (NSTAT $\leq$ NMAX).
2...	2-4	A3	N2	Station name for radiosonde data on each individual card.
2...	11-15	F5.0	P(N)	Surface pressure millibars (mb) at radiosonde station (N) (not read at 00Z).
2...	16-20	F5.1	T(1,N)	Surface temperature (°C)* at radiosonde station (N)
2...	21-25	F5.1	T(2,N)	850 mb temperature (°C) (not read at 00Z).
2...	26-30	F5.1	T(3,N)	700 mb temperature (°C) (not read at 00Z).
2...	31-35	F5.1	T(4,N)	500 mb temperature (°C) (not read at 00Z).
2...	36-40	F5.1	US(N)	Radiosonde station (N) u-component ($m\ s^{-1}$) a the most relevant station-specific pressure level or height above ground.
2...	41-45	F5.1	VS(N)	v-component ($m\ s^{-1}$).

*If available, the user may substitute the afternoon maximum surface temperature for the 00Z radiosonde station temperature.

3.2 Missing Data

Often in the course of processing meteorology data for input to MESOPAC, some data will be missing or unavailable. If data are missing, MESOPAC recognizes this absence and attempts to manage without them. At a minimum, there must be at least one radiosonde station with usable data each 12-hour time step. A MESOPAC run will terminate if all data for every radiosonde station named in the parameter input are missing. If data for more than half of the radiosonde stations named in the parameter input are missing at any given radiosonde time, a warning will be printed by the program.

The missing value indicator '999.0' is entered in all cases of missing input data, except for missing surface pressure data, for which '9999.' is entered. (For line printer output '9999.' indicates a missing mixing depth at a station, and '9' a missing PGT stability.) The missing value indicator should be entered on the station card for any value the user cannot obtain. It is assumed at all times that if the station wind u-component is missing, the v-component is missing as well.

For a missing station wind vector, MESOPAC will use the wind vector for the same station from the previous radiosonde set, or next set, whichever set is closer in time. If two consecutive wind vectors are missing, MESOPAC cannot determine the wind vector at intermediate hours. In this case, that station will be dropped from the computation of both the wind fields and the mechanically produced mixing depth field. If the radiosonde station surface pressure is less than the desired pressure level, then winds at that level are, obviously, unavailable. The user should therefore enter the missing value indicators on the input card for the wind components at this station.

If the 00Z surface temperature is missing at a station, MESOPAC cannot compute the afternoon maximum convective depth at that station. Therefore, the station will not be used in constructing the convectively-produced mixing depth field.

If the temperature at any level in a morning (12Z) radiosonde sounding at a station is missing, MESOPAC will compute the temperature at that level as a linear average of the temperatures measured at adjacent levels. If the temperatures at two or more levels are missing, MESOPAC will not compute a convective depth at that station for that day.

3.3 Model Output

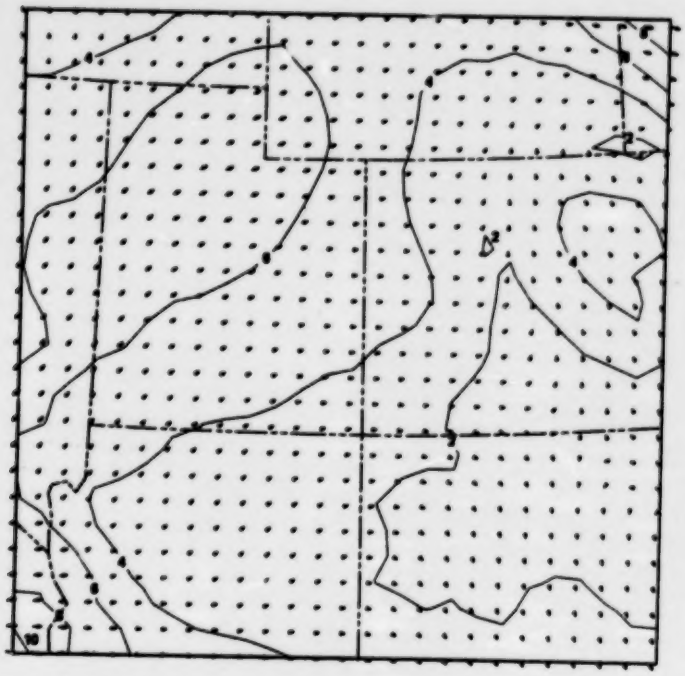
Fields of horizontal (u,v) wind components, mixing depth, and stability are output by MESOPAC through two media: line printer and sequential disk (or tape) file. Line printer output is produced every ISTEP * IPRFRQ hours (if LPRINT = .TRUE.), starting with the initial

hour of the run. Sequential disk or tape output is produced every ISTEP hours (if LTAPE = .TRUE.), also starting with the initial hour of the run. The disk or tape file is output through logical unit 2 in a form completely ready for use by MESOPLUME, MESOPUFF, and MESOGRID.

High quality Calcomp plots of MESOPAC fields can be produced directly from the output sequential disk or tape file by use of MESOPLOT and PLOTVEC, two plotting programs that are part of the MESOFILE post-processing system (Scire et al. 1979). A sample set of plots of wind vector, mixing depth, and stability fields are shown in Figure 3-1.

3.4 MESOPAC Test Case

A test case is contained in this manual to help the potential user to understand the MESOPAC model. Appendix A contains a copy of the input parameter set, as coded on cards for the test case. Appendix B contains a copy of the radiosonde set. Appendix C contains the entire output from the line printer.



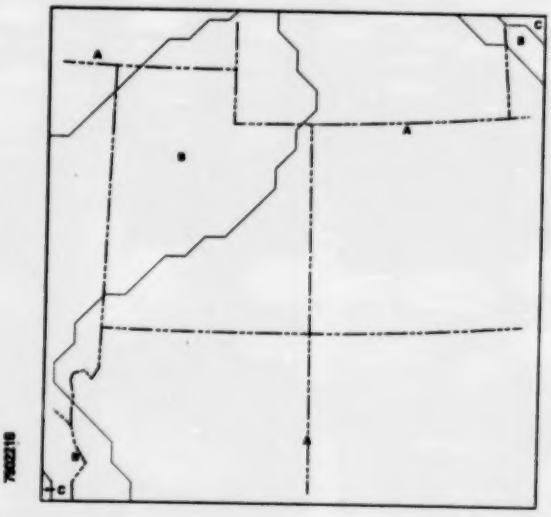


Figure 3-1 Sample Plots of Wind Vector (Top), Mixing Depth (Lower Left), and Stability (Lower Right) Fields

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Scire, J. S., J. E. Beebe, C. W. Benkley, and A. Bass. 1979. Development of Mesoscale Air Quality Simulation Models. Volume 5. User's Guide to the MESOFILE Postprocessing Package. EPA 600/7-79-XXX, Environmental Protection Agency, Research Triangle Park, NC, 67 pp.

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Yu, T. 1978. Determining the Height of the Nocturnal Boundary Layer. J. Appl. Met. 17:28-33.

APPENDIX A

INPUT PARAMETERS

```
MESOPAC USER'S MANUAL TEST CASE
   13    13    18     6     1
1216778    1216878
80000.     0.00001                    1.0                    50
.TRUE.      .TRUE.     .TRUE.
.FALSE.     .TRUE.       1     0
 INW    5.0   1.8
 UCC   -0.3   4.1
 ABQ    9.6   1.8
 GJT    7.3   7.3
 TUS    4.8  -2.0
 DEN   11.4   8.4
 LND    7.6  12.9
 SLC    3.9   9.9
 ELY    0.8   7.8
 BOI   -0.2  13.8
 WMC   -2.1  10.4
 RAP   13.0  14.4
 LBF   15.7  10.7
 DDC   17.4   6.1
 AMA   15.4   2.5
 MAF   14.6  -2.1
 ELP    9.8  -2.6
 SAN   -2.6  -1.4
```

APPENDIX B

INPUT RADIOSONDE DATA

```
1216778      18
 BOI        918.  6.6 10.8  3.5-20.5  7.6 -5.3
 RAP        904. 13.8 13.4  6.8-11.9  5.5 -1.5
 WMC        870.  6.6  8.0 -0.9-23.5  1.4  3.9
 LND       9999.999.0999.0999.0999.0999.0999.0
 SLC        870. 13.8 13.8  5.4-12.7  2.6  7.3
 LBF        910. 18.8 21.8 15.0 -9.1  4.7 -4.0
 ELY       9999.999.0999.0999.0999.0999.0999.0
 GJT       9999.999.0999.0999.0999.0999.0999.0
 DEN       9999.999.0999.0999.0999.0999.0999.0
 DDC        920. 23.2 26.6 15.6 -6.9 11.6  4.2
 UCC       9999.999.0999.0999.0999.0999.0999.0
 INW       9999.999.0999.0999.0999.0999.0999.0
 ABQ       9999.999.0999.0999.0999.0999.0999.0
 AMA        890. 21.6 27.4 16.2 -7.7  8.5  4.9
 SAN       9999.999.0999.0999.0999.0999.0999.0
 TUS       9999.999.0999.0999.0999.0999.0999.0
 ELP       9999.999.0999.0999.0999.0999.0999.0
 MAF        916. 21.0 25.2 14.6 -6.3 -1.5 -0.3
0016878      18
 BOI            20.6                    9.1 -1.6
 RAP            22.2                    4.3  5.1
 WMC            21.6                    3.6 -0.3
 LND           999.0                  999.0999.0
 SLC            25.6                   10.8  0.9
 LBF            28.8                    6.2  3.6
 ELY            21.6                    8.0  5.6
 GJT            31.6                   12.5  7.2
 DEN            31.6                    0.2 -1.0
 DDC            36.6                   10.5 10.5
 UCC           999.0                  999.0999.0
 INW            32.8                    9.8  5.7
 ABQ            34.4                   11.8 -0.0
 AMA            34.4                    5.5  3.8
 SAN            23.4                   18.4  1.6
 TUS            38.4                    3.8 -2.7
 ELP            38.0                    4.5 -1.2
 MAF            34.4                    2.9 -2.1
1216878      18
 BOI        922.  9.4 12.4 -0.7-17.9  7.5 -2.0
 RAP        907. 12.8 10.8 -1.5999.0 14.5 -5.3
 WMC        874.  4.4 12.6  1.0 16.3  3.8 -2.7
 LND        835.  6.8999.0 -1.1 19.7  2.7 -3.8
 SLC        878.  8.8 13.0  0.0 15.1  4.7 -6.7
 LBF        914. 15.0 15.8  8.8  8.7  7.2 -0.0
 ELY        816.  1.8999.0  4.4 14.1  1.0 -1.2
 GJT        856. 17.2 17.4  6.4 12.5  4.7 -4.7
 DEN        839. 13.2999.0  9.4 10.9  6.3 -4.4
 DDC        919. 22.8 28.6 15.6  6.5 13.5  4.9
 UCC       9999.999.0999.0999.0999.0999.0999.0
 INW        855. 10.0 16.8 10.8  7.7  6.5  1.7
 ABQ        841. 15.6999.0 10.6  8.1  4.5 -1.2
 AMA        890. 22.2 26.4 16.0  7.1  8.3  6.9
 SAN       1000. 16.0 23.2 11.0  9.3 12.3 -0.0
 TUS        925. 22.6 26.6 13.2  8.1  6.5 -3.0
 ELP        882. 23.6 28.0 14.8  7.9  6.0 -1.6
 MAF        916. 21.6 20.8 15.6  7.5 -0.3 -0.4
```

APPENDIX C

LINE PRINTER OUTPUT

********** MESOPAC **********

THE FOLLOWING INFORMATION APPLIES TO THIS RUN

13 X 13 HORIZONTAL GRID
18 RADIOSONDE STATIONS
3 RADIOSONDE SETS USED, BEGINNING AT 12 167 78 AND ENDING AT 12 168 78 (HOUR,DAY,YEAR)
COMPUTED MET VARIABLES INTERPOLATED TO 6 HOUR INTERVALS
MET VARIABLES WEIGHTS, ISTEP TO 12 HOURS: 0.50 1.00
WIND FIELDS ARE DIVERGENCE-FREE
MIXING DEPTH FIELD IS COMPUTED
STABILITY FIELD IS COMPUTED
DX= 80000.
KKMAX= 50
EPSI=.0000100
WFRAC= 1.00
NON-FORMATTED FIELDS ARE NOT OUTPUT TO TAPE OR DISK
GRIDDED FIELDS OUTPUT TO LINE PRINTER EVERY 6 HOURS
THE MAXIMUM AFTERNOON CONVECTIVE VALUE IS CONSTRAINED TO OCCUR BY 24Z

STATION LOCATIONS IN GRID COORDINATES (X,Y)

NAME	X	Y
INW	5.0	1.8
UCC	-0.3	4.1
ABQ	9.6	1.8
GJT	7.3	7.3
TUS	4.8	-2.0
DEN	11.4	8.4
LND	7.6	12.9
SLC	3.9	9.9
ELY	0.8	7.8
BOI	-0.2	13.8
WMC	-2.1	10.4
RAP	13.0	14.4
LBF	15.7	10.7
DDC	17.4	6.1
AMA	15.4	2.5
MAF	14.6	-2.1
ELP	9.8	-2.6
SAN	-2.6	-1.4

********** MESOPAC **********

STATION DATA FOR 12 167 78 (HOUR,DAY,YEAR)

STATION	U	V	DEPTH	STAB
INW	999.0	999.0	9999.	9
UCC	999.0	999.0	9999.	9
ABQ	999.0	999.0	9999.	9
GJT	999.0	999.0	9999.	9
TUS	999.0	999.0	9999.	9
DEN	999.0	999.0	9999.	9
LND	999.0	999.0	9999.	9
SLC	2.6	7.3	411.	5
ELY	999.0	999.0	9999.	9
BOI	7.6	-5.3	491.	5
WMC	1.4	3.9	220.	6
MAP	5.5	-1.5	302.	5
LBF	4.7	-4.0	327.	5
DDC	11.6	4.2	654.	4
AMA	8.5	4.9	520.	4
MAF	-1.5	-0.3	81.	6
ELP	999.0	999.0	9999.	9
SAN	999.0	999.0	9999.	9

ONLY NON-MISSING DATA IS USED TO CONSTRUCT ALL FIELDS AT EACH TIME STEP

********** MESOPAC **********

U-FIELD FOR 12 167 78 (HOUR,DAY,YEAR) 4 ITERATIONS SCAN RADIUS= 10.6 GRID SPACES FIELD IN UNITS OF 10** -1

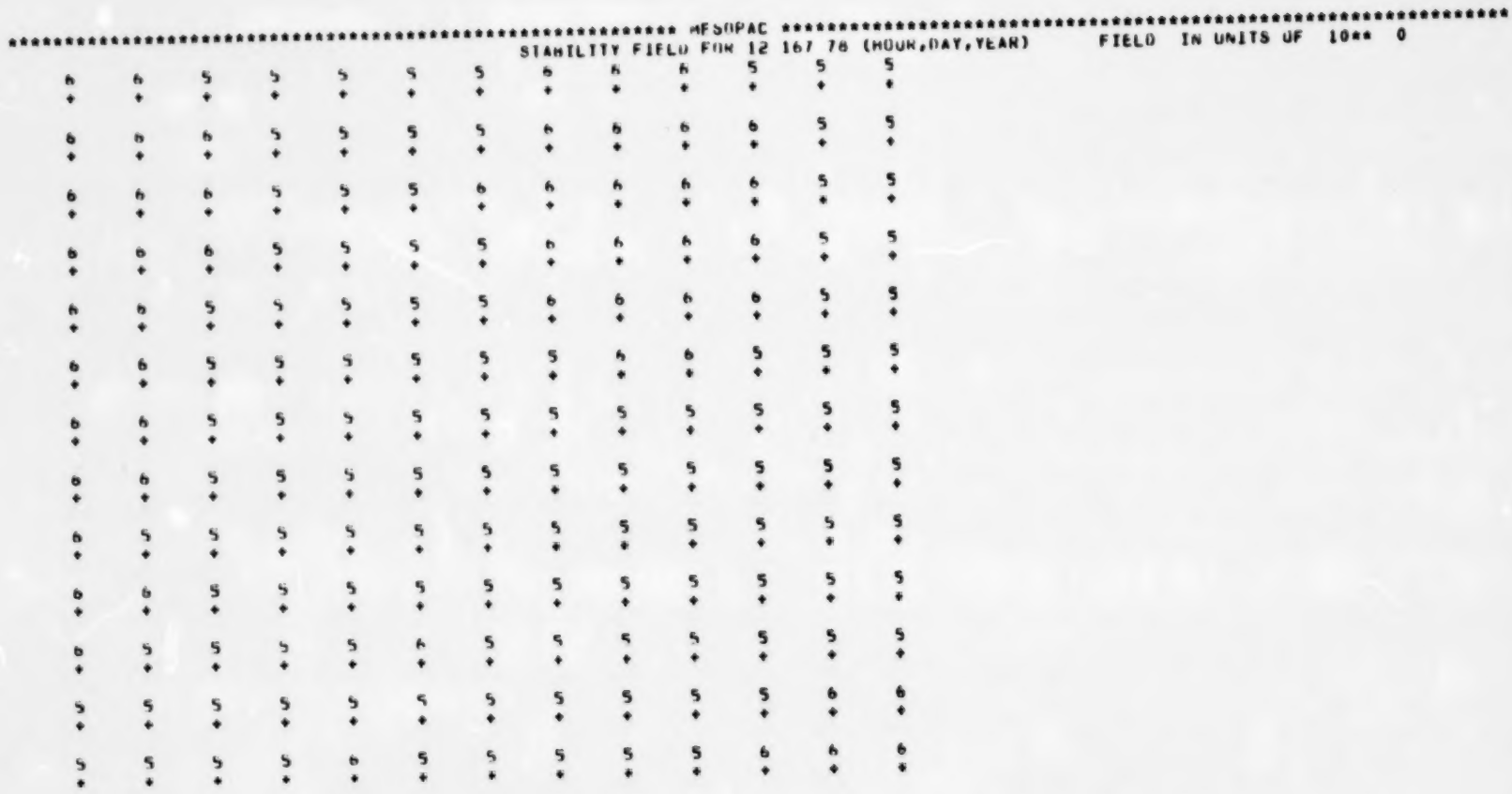
37	48	45	42	40	39	40	41	46	51	55	56	57
22	33	35	36	36	36	38	40	44	50	54	56	58
20	29	35	35	34	34	35	39	43	46	52	56	60
27	31	36	36	35	33	34	39	42	47	51	57	61
32	34	37	36	35	34	35	40	43	49	50	54	59
34	35	38	36	35	35	38	41	44	47	51	55	60
37	36	36	35	34	34	38	45	46	49	52	56	61
34	34	37	37	38	36	39	45	48	52	54	57	60
35	34	32	34	39	43	35	47	47	51	53	56	58
22	29	33	32	37	38	35	45	46	51	50	54	54
13	21	27	35	32	28	35	33	42	45	49	50	48
18	19	19	32	24	30	33	33	39	41	43	43	40
19	18	21	32	18	30	28	31	31	39	33	34	30

```
********************************************************** MESOPAC ***************************************************************
V-FIELD FOR 12 167 78 (HOUR,DAY,YEAR)        4 ITERATIONS      SCAN RADIUS= 10.6 GRID SPACES      FIELD  IN UNITS OF  10** -1
     3    12    36    54    58    50    37    22    10     1     2     4    10
     -     +     +     +     +     +     +     +     +     +     -     -     -

     9    16    33    52    57    51    39    27    16     7     1     2     8
     +     +     +     +     +     +     +     +     +     +     +     -     -

    21    25    38    54    58    52    41    29    21    11     4     1     4
     +     +     +     +     +     +     +     +     +     +     +     +     -

    28    31    41    53    58    54    45    35    24    17    13     5     1
     +     +     +     +     +     +     +     +     +     +     +     +     +

    32    35    44    53    56    51    45    36    29    20    14    10     7
     +     +     +     +     +     +     +     +     +     +     +     +     +

    34    38    44    52    56    54    48    39    32    24    19    15    14
     +     +     +     +     +     +     +     +     +     +     +     +     +

    36    40    46    51    53    53    46    35    33    26    22    20    19
     +     +     +     +     +     +     +     +     +     +     +     +     +

    35    40    44    52    51    52    47    36    30    26    24    23    25
     +     +     +     +     +     +     +     +     +     +     +     +     +

    39    44    49    53    49    48    45    34    33    29    25    25    27
     +     +     +     +     +     +     +     +     +     +     +     +     +

    38    40    45    60    58    44    45    43    30    30    29    28    30
     +     +     +     +     +     +     +     +     +     +     +     +     +

    52    53    53    58    55    44    46    43    38    33    29    30    29
     +     +     +     +     +     +     +     +     +     +     +     +     +

    54    53    59    66    52    49    48    48    41    36    35    28    27
     +     +     +     +     +     +     +     +     +     +     +     +     +

    55    55    69    64    51    56    49    51    47    37    33    27    24
     +     +     +     +     +     +     +     +     +     +     +     +     +
```

********** MESOPAC **********

MIXING DEPTH FIELD FOR 12 167 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

199	263	307	364	372	334	289	248	249	270	291	296	306
126	196	258	337	359	334	291	255	250	266	284	295	310
157	203	273	340	358	330	286	255	255	250	278	297	316
204	230	288	340	358	336	296	278	256	266	281	303	325
242	260	306	337	351	326	301	285	275	280	276	291	317
256	272	309	338	352	340	324	302	286	280	288	301	328
272	284	311	326	337	334	316	302	301	296	300	317	339
257	278	303	338	335	333	325	306	300	307	313	324	342
275	294	311	335	334	344	304	308	306	309	311	327	340
235	262	293	356	366	307	302	327	291	312	307	324	328
284	305	316	360	338	277	315	288	301	295	301	310	295
304	298	330	366	304	303	308	309	302	288	296	273	255
309	306	384	360	287	335	298	315	301	269	247	229	202


MESOPAC
STABILITY FIELD FOR 12 167 78 (HOUR,DAY,YEAR)
FIELD IN UNITS OF 10** 0

********** MESOPAC **********

STATION DATA FOR 18 167 78 (HOUR,DAY,YEAR)

STATION	U	V	DEPTH	STAB
INW	9.8	5.7	9999.	9
UCC	999.0	999.0	9999.	9
ABQ	11.8	0.0	9999.	9
GJT	12.5	7.2	9999.	9
TUS	3.8	-2.7	9999.	9
DEN	0.2	-1.0	9999.	9
LND	999.0	999.0	9999.	9
SLC	6.7	4.1	1348.	2
ELY	8.0	5.6	9999.	9
BOI	8.4	-3.5	665.	3
WMC	2.5	1.8	2164.	1
RAP	4.9	1.8	592.	2
LBF	5.4	-0.2	406.	3
DDC	11.1	7.3	866.	4
AMA	7.0	4.3	714.	3
MAF	0.7	-1.2	752.	1
ELP	4.5	-1.2	9999.	9
SAN	18.4	1.6	9999.	9

ONLY NON-MISSING DATA IS USED TO CONSTRUCT ALL FIELDS AT EACH TIME STEP

```
********************************************************** MESOPAC ***************************************************************
U-FIELD FOR 18 167 78 (HOUR,DAY,YEAR)        6 ITERATIONS      SCAN RADIUS=  4.9 GRID SPACES      FIELD  IN UNITS OF  10** -1
    56    67    70    72    76    79    77    76    57    53    38    47    42
     +     +     +     +     +     +     +     +     +     +     +     +     +

    47    60    68    70    74    71    71    64    59    56    52    51    44
     +     +     +     +     +     +     +     +     +     +     +     +     +

    46    60    69    72    71    68    66    60    61    59    57    47    40
     +     +     +     +     +     +     +     +     +     +     +     +     +

    58    69    73    75    74    74    75    72    69    61    50    40    38
     +     +     +     +     +     +     +     +     +     +     +     +     +

    72    77    79    82    83    88    88    86    81    68    53    43    45
     +     +     +     +     +     +     +     +     +     +     +     +     +

    78    79    82    87    92    97    99    95    87    73    61    53    58
     +     +     +     +     +     +     +     +     +     +     +     +     +

    78    81    86    92    96    100   100   92    85    75    73    73    82
     +     +     +     +     +     +     +     +     +     +     +     +     +

    84    91    91    97    99    103   101   99    88    83    80    85    88
     +     +     +     +     +     +     +     +     +     +     +     +     +

    89    88    101   102   102   104   103   103   100   91    93    92    93
     +     +     +     +     +     +     +     +     +     +     +     +     +

   117   106   104    96    95    97    101   105   105   102   104   107   10.
     +     +     +     +     +     +     +     +     +     +     +     +     +

   143   134    99   100    96    99    98    100   95    103   103   105   97
     +     +     +     +     +     +     +     +     +     +     +     +     +

   144   126   109    99    95    92    89    86    90    95    99    92    85
     +     +     +     +     +     +     +     +     +     +     +     +     +

   132   109   102    81    78    74    70    73    77    83    83    76    69
     +     +     +     +     +     +     +     +     +     +     +     +     +
```

********** MESOPAC **********

V-FIELD FOR 18 167 78 (HOUR,DAY,YEAR) 6 ITERATIONS SCAN RADIUS= 4.9 GRID SPACES FIELD IN UNITS OF 10** -1

3	13	28	34	39	48	59	72	70	62	38	19	12
13	20	29	37	43	48	58	60	57	51	35	21	7
27	34	36	40	40	44	52	58	61	53	33	11	2
40	41	39	39	39	44	52	56	57	46	22	5	6
48	48	41	41	39	46	52	54	53	35	11	1	6
49	48	44	43	45	49	54	53	42	20	2	3	2
51	52	48	49	50	53	53	46	33	11	8	4	5
54	55	53	50	52	53	49	40	27	8	3	4	14
61	58	53	55	53	52	47	33	18	2	5	3	11
50	63	62	47	52	53	45	35	14	0	0	4	15
40	44	42	44	52	55	51	34	13	0	1	4	8
28	24	29	44	49	53	44	30	17	8	1	3	2
4	8	18	31	46	48	42	34	22	11	3	10	6

********** MESOPAC **********

MIXING DEPTH FIELD FOR 18 167 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

1165	1137	1207	1254	1281	1245	1193	1108	990	792	709	650	608
1560	1374	1330	1326	1334	1303	1245	1155	1029	818	733	668	614
1719	1491	1361	1346	1348	1328	1273	1170	1036	925	755	688	629
1723	1529	1408	1361	1346	1323	1273	1151	1044	854	779	710	655
1679	1539	1436	1384	1347	1303	1232	1134	1038	855	788	732	691
1635	1538	1460	1411	1387	1331	1200	1107	1023	854	793	748	718
1601	1533	1475	1435	1408	1334	1168	1054	1009	841	792	758	737
1575	1527	1483	1446	1424	1322	1287	1101	874	827	789	762	745
1555	1520	1486	1456	1436	1306	1263	925	878	836	783	762	747
1540	1513	1487	1654	1627	1283	1218	961	854	820	792	770	754
1763	1731	1699	1671	1647	1240	980	939	892	808	785	767	724
1760	1733	1708	1684	1114	978	944	908	870	841	815	726	728
1757	1735	1348	1348	1076	947	916	884	852	757	755	752	750

********** MESOPAC **********

STABILITY FIELD FOR 18 167 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

```
2 2 2 2 2 2 2 3 3 3 2 2 2
1 2 2 2 2 2 2 2 2 2 2 2 2
1 2 2 2 2 2 2 2 2 3 2 2 2
2 2 2 2 2 2 2 2 2 3 2 2 2
2 2 2 2 2 3 3 3 2 3 2 2 2
2 2 2 2 3 3 3 3 2 2 2 2 2
2 2 3 3 3 3 3 3 2 2 2 2 3
3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3 3 3 3 3 3 3 3 3 3 3
3 3 3 2 2 3 3 3 3 3 3 3 2
```

********** MESOPAC **********

STATION DATA FOR 0 168 78 (HOUR,DAY,YEAR)

STATION	U	V	DEPTH	STAB
INW	9.8	5.7	9999.	9
UCC	999.0	999.0	9999.	9
ABQ	11.8	0.0	9999.	9
GJT	12.5	7.2	9999.	9
TUS	3.8	-2.7	9999.	9
DEN	0.2	-1.0	9999.	9
LND	999.0	999.0	9999.	9
SLC	10.8	0.9	2697.	3
ELY	8.0	5.6	9999.	9
BOI	9.1	-1.6	1330.	2
AMC	3.6	-0.3	4327.	1
MAP	4.3	5.1	1183.	2
LBF	6.2	3.6	811.	2
DDC	10.5	10.5	1733.	3
AMA	5.5	5.8	1429.	2
MAF	2.9	-2.1	1505.	1
ELP	4.5	-1.2	9999.	9
SAN	18.4	1.6	9999.	9

ONLY NON-MISSING DATA IS USED TO CONSTRUCT ALL FIELDS AT EACH TIME STEP

********** MESOPAC **********

U-FIELD FOR 0 168 78 (HOUR,DAY,YEAR) 6 ITERATIONS SCAN RADIUS= 4.9 GRID SPACES FIELD IN UNITS OF 10** -1

73	82	89	94	100	105	103	98	76	60	40	46	37
66	78	89	94	99	95	96	85	80	69	58	54	41
60	77	90	96	96	90	89	79	80	76	67	53	39
63	77	84	91	94	94	93	88	83	74	61	46	40
72	77	80	87	93	99	98	95	91	76	62	48	50
80	81	80	87	95	104	106	102	94	79	67	58	63
77	83	87	93	99	106	107	98	90	79	78	77	85
81	89	91	98	102	108	107	103	92	86	83	87	90
85	84	96	99	100	104	105	105	102	93	95	93	93
115	104	101	94	93	96	101	106	107	103	105	107	106
141	131	96	99	95	99	98	100	96	104	104	106	99
143	125	108	98	94	92	89	86	91	95	100	93	87
131	108	101	81	78	74	70	73	78	84	85	78	73

```
********************************************************** MESOPAC ***************************************************************
V-FIELD FOR  0 168 78 (HOUR,DAY,YEAR)        6 ITERATIONS      SCAN RADIUS=  4.9 GRID SPACES      FIELD  IN UNITS OF  10** -1
     1     5     9    11    19    32    53    72    76    80    56    38    35
     -     +     +     +     +     +     +     +     +     +     +     +     +

     7    12    15    15    24    33    49    57    55    59    48    36    26
     +     +     +     +     +     +     +     +     +     +     +     +     +

    21    28    25    20    19    29    43    54    60    55    41    21     9
     +     +     +     +     +     +     +     +     +     +     +     +     +

    36    40    32    22    19    27    41    49    52    44    25     9     1
     +     +     +     +     +     +     +     +     +     +     +     +     -

    46    48    38    29    21    29    40    47    48    33    11     0     4
     +     +     +     +     +     +     +     +     +     +     +     +     -

    46    48    41    35    31    34    42    47    37    17     3     3     1
     +     +     +     +     +     +     +     +     +     +     -     -     +

    49    50    45    43    39    41    43    40    29     8     8     4     4
     +     +     +     +     +     +     +     +     +     +     -     -     +

    54    56    49    44    44    44    41    35    24     5     4     3    13
     +     +     +     +     +     +     +     +     +     +     -     +     +

    60    58    52    51    47    46    41    28    14     0     6     2     9
     +     +     +     +     +     +     +     +     +     -     -     +     +

    49    63    60    43    48    48    41    32    11     2     2     1    12
     +     +     +     +     +     +     +     +     +     -     -     +     +

    39    43    40    41    48    51    46    30     9     2     2     1     4
     +     +     +     +     +     +     +     +     +     -     -     +     +

    27    23    26    42    45    50    40    27    13     5     1     5     2
     +     +     +     +     +     +     +     +     +     +     -     -     -

     3     7    11    28    43    45    38    30    19     8     6    12     9
     +     +     +     +     +     +     +     +     +     +     -     -     -
```

```
********************************************************** MESOPAC **********************************************************************
                                        MIXING DEPTH FIELD FOR  0 168 78 (HOUR,DAY,YEAR)    FIELD  IN UNITS OF  10**  0

 2331  2274  2414  2508  2562  2490  2386  2216  1979  1585  1417  1299  1217
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3120  2749  2660  2651  2667  2607  2491  2311  2059  1637  1466  1336  1228
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3439  2981  2762  2692  2697  2657  2546  2340  2072  1849  1509  1376  1258
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3446  3058  2817  2722  2692  2645  2547  2302  2088  1707  1558  1419  1310
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3358  3077  2873  2769  2693  2607  2465  2268  2076  1710  1576  1464  1382
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3270  3076  2919  2822  2775  2661  2401  2215  2047  1708  1585  1496  1457
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3202  3066  2950  2866  2815  2668  2335  2108  2017  1682  1585  1516  1474
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3150  3054  2966  2897  2848  2645  2574  2202  1749  1653  1577  1523  1491
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3111  3039  2972  2916  2872  2612  2525  1850  1757  1672  1567  1523  1495
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3080  3025  2973  3308  3253  2565  2437  1922  1709  1641  1585  1541  1508
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3526  3462  3399  3342  3295  2481  1960  1878  1783  1616  1571  1534  1447
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3519  3467  3415  3368  2227  1956  1889  1815  1740  1682  1629  1451  1456
    +     +     +     +     +     +     +     +     +     +     +     +     +

 3514  3471  2697  2697  2153  1894  1832  1767  1704  1513  1509  1504  1500
    +     +     +     +     +     +     +     +     +     +     +     +     +
```

STABILITY FIELD FOR 0 168 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

```
 2  2  2  2  3  3  3  3  3  3  2  2  1
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  2  2  2  3  3  3  3  2  2  2  2  1
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  2  2  3  3  2  3  2  3  2  2  2  1
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  2  2  2  2  2  3  3  3  2  2  1  1
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  2  2  2  2  3  3  3  3  2  2  1  1
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  2  2  2  3  3  3  3  3  2  2  2  2
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  2  3  3  3  3  3  3  2  2  2  2  2
 +  +  +  +  +  +  +  +  +  +  +  +  +

 2  3  3  3  3  3  3  3  2  2  2  2  2
 +  +  +  +  +  +  +  +  +  +  +  +  +

 3  3  3  3  3  3  3  3  3  2  2  2  2
 +  +  +  +  +  +  +  +  +  +  +  +  +

 3  3  3  3  3  3  3  3  3  3  3  3  3
 +  +  +  +  +  +  +  +  +  +  +  +  +

 3  3  3  3  3  3  3  3  2  3  3  3  3
 +  +  +  +  +  +  +  +  +  +  +  +  +

 3  3  3  3  3  3  2  2  2  2  3  2  2
 +  +  +  +  +  +  +  +  +  +  +  +  +

 3  3  3  2  2  2  2  2  2  2  2  2  2
 +  +  +  +  +  +  +  +  +  +  +  +  +
```

********** MESOPAC **********

STATION DATA FOR 6 168 78 (HOUR,DAY,YEAR)

STATION	U	V	DEPTH	STAB
INW	8.2	3.7	474.	5
UCC	999.0	999.0	9999.	9
ABQ	8.2	-0.6	433.	5
GJT	8.6	1.3	461.	5
TUS	5.1	-2.8	312.	5
DEN	3.2	-2.7	224.	6
LND	2.7	-3.8	247.	6
SLC	7.8	-2.9	439.	5
ELY	4.5	2.2	265.	6
HUI	8.3	-1.8	450.	5
WMC	3.7	-1.5	212.	6
RAP	9.4	-0.1	498.	5
LBF	6.7	1.8	368.	5
DDC	12.0	7.7	756.	4
AMA	6.9	5.3	463.	5
MAF	1.3	-1.3	96.	6
ELP	5.3	-1.4	288.	6
SAN	15.3	0.8	815.	4

ONLY NON-MISSING DATA IS USED TO CONSTRUCT ALL FIELDS AT EACH TIME STEP

********** MESOPAC **********

U-FIELD FOR 6 168 78 (HOUR,DAY,YEAR) 6 ITERATIONS SCAN RADIUS= 4.9 GRID SPACES FIELD IN UNITS OF 10** -1

62	66	67	63	59	53	44	37	37	45	50	61	63
53	59	64	64	62	57	52	48	50	55	59	63	60
41	52	60	65	64	60	60	59	62	63	65	61	55
36	45	52	60	62	63	65	66	68	66	63	57	54
37	41	44	52	59	68	71	73	74	68	65	59	61
42	43	43	51	61	71	77	76	76	70	68	63	70
40	45	50	57	64	72	77	74	74	70	71	72	84
40	50	54	62	68	74	79	79	76	74	74	78	86
44	50	60	67	70	78	80	81	81	77	80	81	87
78	74	74	71	72	75	79	82	82	80	83	86	87
111	105	80	81	77	79	79	79	76	79	81	83	78
118	106	92	83	79	76	73	71	72	74	76	73	69
112	95	90	75	72	68	64	65	66	69	68	64	60

```
********************************************************** MESOPAC ***********************************************************
V-FIELD FOR  6 16H 78 (HOUR,DAY,YEAR)        6 ITERATIONS      SCAN RADIUS=  4.9 GRID SPACES      FIELD  IN UNITS OF  10** -1
   11    9    8   12    9    2    2    2    7    9   11   11    8
    -    -    -    -    -    -    +    -    -    -    -    -    -

    9    7   11   18   15   11    8    7    4    3    4    6    7
    -    -    -    -    -    -    -    -    -    -    -    -    -

    0    2    5   15   17   18   10    5    1    0    4   11   15
    -    +    -    -    -    -    -    -    +    -    -    -    -

    6    9    0   15   20   17   10    4    1    0    7   15   20
    +    +    -    -    -    -    -    -    +    -    -    -    -

   15   16    8    6   14   11    5    0    1    5   13   20   21
    +    +    +    -    -    -    -    +    +    -    -    -    -

   14   16   10    0    4    8    0    3    2    8   17   20   17
    +    +    +    +    -    -    -    +    -    -    -    -    -

   16   18   15   12    7    6    4    3    2   12   21   18    9
    +    +    +    +    +    +    +    +    -    -    -    -    -

   20   24   20   14   14   13   10    6    1   10   17    9    2
    +    +    +    +    +    +    +    +    -    -    -    -    +

   30   29   25   24   20   18   14    8    4   13   18    7    5
    +    +    +    +    +    +    +    +    -    -    -    -    +

   28   36   33   21   24   22   15    8    5   12   13    2   12
    +    +    +    +    +    +    +    +    -    -    -    -    +

   21   23   20   21   23   24   19    6    8   13   12    4    5
    +    +    +    +    +    +    +    +    -    -    -    -    +

   14    8    8   19   20   23   14    8    6    9   10    6    2
    +    +    +    +    +    +    +    +    -    -    -    -    +

    5    3    3    8   16   17   11    8    4    9   14   11    5
    -    -    -    +    +    +    +    +    -    -    -    -    -
```

********** MESOPAC **********

MIXING DEPTH FIELD FOR 6 168 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

333	352	359	339	318	282	234	198	202	241	274	330	337
283	317	346	351	340	308	280	255	266	291	313	333	321
218	274	321	354	353	328	320	312	328	336	344	326	300
196	246	275	325	345	347	346	349	362	348	336	311	306
211	232	238	277	323	367	377	388	390	364	350	328	341
237	244	233	269	323	378	409	404	400	375	371	350	383
230	255	276	306	339	384	408	392	391	378	392	393	448
239	293	306	335	367	398	420	418	402	397	402	416	457
282	309	347	377	387	422	428	428	429	413	433	430	463
440	438	430	392	404	416	429	435	436	426	444	455	468
598	572	436	445	426	438	431	419	407	426	433	438	413
628	561	488	452	431	423	395	374	385	395	407	388	365
595	506	460	400	394	373	346	344	353	368	366	344	316

********** MESOPAC **********

STABILITY FIELD FOR 6 168 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

```
 5  5  5  5  5  6  6  6  6  6  6  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  5  5  5  5  5  6  6  6  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  6  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  6  6  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  6  6  6  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  6  6  6  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  6  6  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  5  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 6  5  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 5  5  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 4  4  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 4  4  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *

 4  5  5  5  5  5  5  5  5  5  5  5  5
 *  *  *  *  *  *  *  *  *  *  *  *  *
```

********** MESOPAC **********

STATION DATA FOR 12 168 78 (HOUR,DAY,YEAR)

STATION	U	V	DEPTH	STAB
INW	6.5	1.7	356.	5
UCC	999.0	999.0	9999.	9
ABQ	4.5	-1.2	247.	6
GJT	4.7	-4.7	352.	5
TUS	6.5	-3.0	379.	5
DEN	6.3	-4.4	407.	5
LND	2.7	-3.8	247.	6
SLC	4.7	-6.7	434.	5
ELY	1.0	-1.2	83.	6
BOI	7.5	-2.0	411.	5
WMC	3.8	-2.7	247.	6
RAP	14.5	-5.3	618.	4
LBF	7.2	0.0	382.	5
ODC	13.5	4.4	761.	4
AMA	8.3	6.9	572.	4
MAF	-0.3	-0.4	26.	6
ELP	6.0	-1.6	329.	5
SAN	12.3	0.0	652.	4

ONLY NON-MISSING DATA IS USED TO CONSTRUCT ALL FIELDS AT EACH TIME STEP

```
********************************************************** MESOPAC **********************************************************
U-FIELD FOR 12 168 76 (HOUR,DAY,YEAR)        5 ITERATIONS      SCAN RADIUS=  4.9 GRID SPACES      FIELD  IN UNITS OF  10** -1
   54    53    51    46    41    38    36    35    37    49    62    78    87
    +     +     +     +     +     +     +     +     +     +     +     +     +

   43    45    46    45    42    41    42    41    43    51    59    67    72
    +     +     +     +     +     +     +     +     +     +     +     +     +

   28    32    39    42    43    44    47    50    52    54    60    62    62
    +     +     +     +     +     +     +     +     +     +     +     +     +

   14    19    26    35    40    45    48    51    54    55    59    60    60
    +     +     +     +     +     +     +     +     +     +     +     +     +

    6     9    14    22    35    43    48    51    54    57    62    64    65
    +     +     +     +     +     +     +     +     +     +     +     +     +

    9     9    10    18    30    41    49    50    55    57    63    63    72
    +     +     +     +     +     +     +     +     +     +     +     +     +

    8    10    16    25    32    40    46    49    55    58    61    63    79
    +     +     +     +     +     +     +     +     +     +     +     +     +

    2    13    20    28    36    42    51    54    58    60    62    66    79
    +     +     +     +     +     +     +     +     +     +     +     +     +

    6    20    27    38    43    52    54    56    57    59    62    66    78
    +     +     +     +     +     +     +     +     +     +     +     +     +

   43    46    48    49    53    55    58    57    56    55    58    63    67
    +     +     +     +     +     +     +     +     +     +     +     +     +

   83    81    65    65    60    60    60    57    55    53    56    58    55
    +     +     +     +     +     +     +     +     +     +     +     +     +

   93    87    76    69    64    61    57    54    53    52    51    52    50
    +     +     +     +     +     +     +     +     +     +     +     +     +

   94    84    80    70    68    62    59    56    54    53    50    49    46
    +     +     +     +     +     +     +     +     +     +     +     +     +
```

```
********************************************************** MESOPAC **********************************************************
V-FIELD FOR 12 16R 78 (HOUR,DAY,YEAR)        5 ITERATIONS      SCAN RADIUS=  4.9 GRID SPACES      FIELD  IN UNITS OF  10** -1
   24    27    35    46    50    50    44    42    47    55    56    51    43
    -     -     -     -     -     -     -     -     -     -     -     -     -

   26    30    40    52    55    53    48    44    41    44    43    39    36
    -     -     -     -     -     -     -     -     -     -     -     -     -

   22    25    36    51    55    51    46    42    38    39    40    38    36
    -     -     -     -     -     -     -     -     -     -     -     -     -

   20    21    32    49    55    50    45    41    39    37    35    37    38
    -     -     -     -     -     -     -     -     -     -     -     -     -

   16    15    22    38    47    44    40    37    36    35    35    38    37
    -     -     -     -     -     -     -     -     -     -     -     -     -

   17    14    20    32    34    36    36    35    35    30    30    35    35
    -     -     -     -     -     -     -     -     -     -     -     -     -

   17    13    14    18    23    25    30    29    29    28    31    30    22
    -     -     -     -     -     -     -     -     -     -     -     -     -

   14     6     7    14    13    16    18    20    23    24    27    20     9
    -     -     -     -     -     -     -     -     -     -     -     -     -

    0     2     1     2     6     6    10    17    20    23    27    15     1
    -     +     +     -     -     -     -     -     -     -     -     -     +

    7    11     8     0     2     2     7    13    19    20    21     5    12
    +     +     +     +     +     -     -     -     -     -     -     -     +

    3     5     3     2     1     0     5    16    22    21    20     8     7
    +     +     +     +     +     -     -     -     -     -     -     -     +

    0     5     8     3     3     2     9    17    22    21    17     6     6
    +     -     -     -     -     -     -     -     -     -     -     -     +

   12    13    17    11     8     8    13    20    25    25    21     9     1
    -     -     -     -     -     -     -     -     -     -     -     -     +
```

********** MESOPAC **********

MIXING DEPTH FIELD FOR 12 168 78 (HOUR,DAY,YEAR) FIELD IN UNITS OF 10** 0

310	317	326	343	344	333	304	286	318	391	443	491	515
265	284	323	363	367	357	338	319	317	355	387	411	426
188	216	280	351	372	357	349	345	344	353	382	386	377
129	148	217	320	361	356	347	349	355	350	365	375	377
91	92	140	234	302	325	329	335	346	355	379	392	399
102	88	118	193	243	290	320	321	345	341	371	381	423
98	89	114	155	207	250	292	304	329	340	361	369	434
73	75	113	166	202	236	284	304	330	344	360	366	424
34	104	142	200	229	279	292	309	321	334	356	357	415
232	249	260	262	281	293	310	311	314	310	330	333	359
440	430	344	346	320	318	318	313	315	305	314	309	293
493	460	407	367	339	323	306	301	307	297	287	278	267
501	448	435	376	361	331	318	318	317	310	285	264	243

```
********************************************************** MESOPAC ***********************************************************
                                  STABILITY FIELD FOR 12 160 78 (HOUR,DAY,YEAR)      FIELD  IN UNITS OF  10**  0

     5    5    5    5    5    5    5    6    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    5    5    5    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    5    5    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    5    5    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    6    5    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    6    6    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    6    6    6    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    6    6    6    6    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    6    6    6    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     6    6    6    6    6    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     5    5    5    5    5    5    5    5    5    5    5    5    5
     +    +    +    +    +    +    +    +    +    +    +    +    +

     5    5    5    5    5    5    5    5    5    5    6    6    6
     +    +    +    +    +    +    +    +    +    +    +    +    +

     5    5    5    5    5    5    5    5    5    5    6    6    6
     +    +    +    +    +    +    +    +    +    +    +    +    +
```